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UTAH GEOLOGICAL SURVEY: A VALUABLE PARTNER IN THE MANAGEMENT OF FEDERAL FOSSIL RESOURCES

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Abstract—The Utah Geological Survey has a legislative mandate to insure that Utah's paleontological heritage benefits its citizens. One of the largest state geological surveys, the Utah Geological Survey has a depth of expertise and facilities that it can bring to bear as it works with various federal, state, local, educational, and private agencies to document and manage important paleontological resources for the maximum public scientific and educational benefit.

INTRODUCTION

The extraordinary sedimentary geology of Utah is reflected in its many geological state and federal parks and monuments (Stokes, 1986; Hintze, 1993, 2005; Sprinkel et al., 2003; Hamblin, 2004). Contained within these rocks is a remarkable fossil record that ranges from common invertebrate and plant fossils to unique vertebrate fossils (e.g. Kirkland, 2005). The American people have a proven interest in these fossil resources; both for the opportunities to make their own discoveries and to learn more about the history of life on Earth. As land managers and scientists, we have obligations to protect this important scientific and educational resource and to learn from and interpret the resource for the maximum public benefit. The Utah Geological Survey (UGS) is charged by the State of Utah with providing timely, independent information and advice to federal, state, and local governments, and to the general public about Utah's geologic resources (e.g. oil, gas, coal and minerals), hazards (e.g. earthquakes, landslides, debris flows and rock falls) and the geologic environment (e.g. ground water and fossils) to promote economic development and assist with wise land-use decisions. Within the Utah Code regarding the mission of the UGS under Title 63 State Affairs in General, Chapter 73 Geological Survey, sections 63-73-1 (3)-(6), (9)-(12), (15)-(17), 63-73-6 (1) (l)-(p), and 63-73-11-20 all relate to paleontology (http://www.le.state.ut.us/~code/TITLE63/63_2D.htm). To facilitate these responsibilities, the State Geologist assigns certain tasks to a State Paleontologist and his/her staff. These mandated tasks include: (1) maintaining a paleontological locality database; (2) issuing permits for paleontological studies on state lands; (3) commenting on issues and development projects affecting paleontological resources in Utah; (4) promoting the significance of Utah's paleontological resources and heritage; (5) monitoring activities involving paleontology in Utah; (6) serving as partner with federal, state, and local agencies and educational organizations regarding paleontology in Utah; (7) advising, overseeing training programs, and providing opportunities for involvement for Utah's statewide paleontological volunteer organization, the Utah Friends of Paleontology; and (8) conducting research on Utah's paleontological resources.

UTAH PALEONTOLOGICAL LOCALITY DATABASE

The office of the State Paleontologist at the UGS has been working for the past 20 years to develop a comprehensive digital paleontological locality database for all fossil sites in the state of Utah. The Bureau of Land Management (BLM) has helped fund this endeavor over the last several years through a memorandum of understanding with the UGS, as part the BLM's mandate under the Antiquities Act of 1906 and BLM Organic Act of 1977. The information in the database can be queried and sorted in a multitude of ways to address specific research and management questions, and maps can be created using Geographic Information Systems (GIS) software. Following federal guidelines, the UGS considers significant fossils sites to be: (1) all sites preserving vertebrate fossils and their traces; (2) sites of exceptional fossil occurrence; (3) sites of exceptional fossil preservation; and (4) sites preserving rare fossils. Fossils that are not considered to be significant include: (1) common invertebrates; (2) common fossil plants; and (3) microfossils. The Utah Code restricts access to these data to qualified agencies and researchers.

UGS PALEONTOLOGICAL SENSITIVITY MAPS

The office of the State Paleontologist at the UGS has also been using GIS to integrate existing digital geologic maps produced by the UGS with the UGS Paleontological Locality Database to generate paleontological sensitivity maps. We have developed these maps for public lands in Utah, assigning sensitivity levels to the different geologic units based on the type and distribution of fossils. These maps can serve as a basis for paleontological resource management by aiding land managers in making decisions regarding the protection of fossil resources (DeBlieux et al., 2003; 2004).

The office of the State Paleontologist has defined six levels of sensitivity for map units for the purpose of developing paleontological sensitivity maps. This sensitivity scale starts at five for the most sensitive rock units and decreases to zero for rock units that do not preserve fossil resources. This scale is as follows:

(5) Significant fossils are abundant and widespread (e.g. Morrison and Uinta formations).
(4) Significant fossils are present (e.g. Chinle and Cedar Mountain formations).
(3) Significant fossil sites are known (e.g. Mancos Shale, Wahweap and Green River formations).
(2) Common fossils may be abundant, but significant fossils are rare. This category includes most Paleozoic formations and Pleistocene deposits.
(1) Significant fossils are rare (e.g. Navajo Sandstone and Uinta Mountain Group).
(0) Map units represent rocks in which fossils are not pre served, such as igneous and high-grade metamorphic rocks.

The BLM has 1-3 paleontological sensitivity scale that would translate as follows:

(1) Most sensitive = UGS 5 & 4
(2) Moderately sensitive = UGS 3 & 2
(3) Low sensitivity = UGS 1 & 0

The quality of the paleontological sensitivity maps is directly related to the level of detail in the geological map. The statewide Utah Paleontological Sensitivity Map (Fig. 1) was developed from the Digital Geological Map of Utah (Hintze et al., 2000). A significant weakness of this map, beyond its small scale (1:500,000), is that most formations are mapped together in groups. The UGS is in the process of completing 30' X 60' (1:100,000 scale) digital geological maps for Utah that will facilitate improved resolution of the state paleontological sensitivity map. On the 7.5' (1:24,000 scale) quadrangle maps being produced by the UGS,

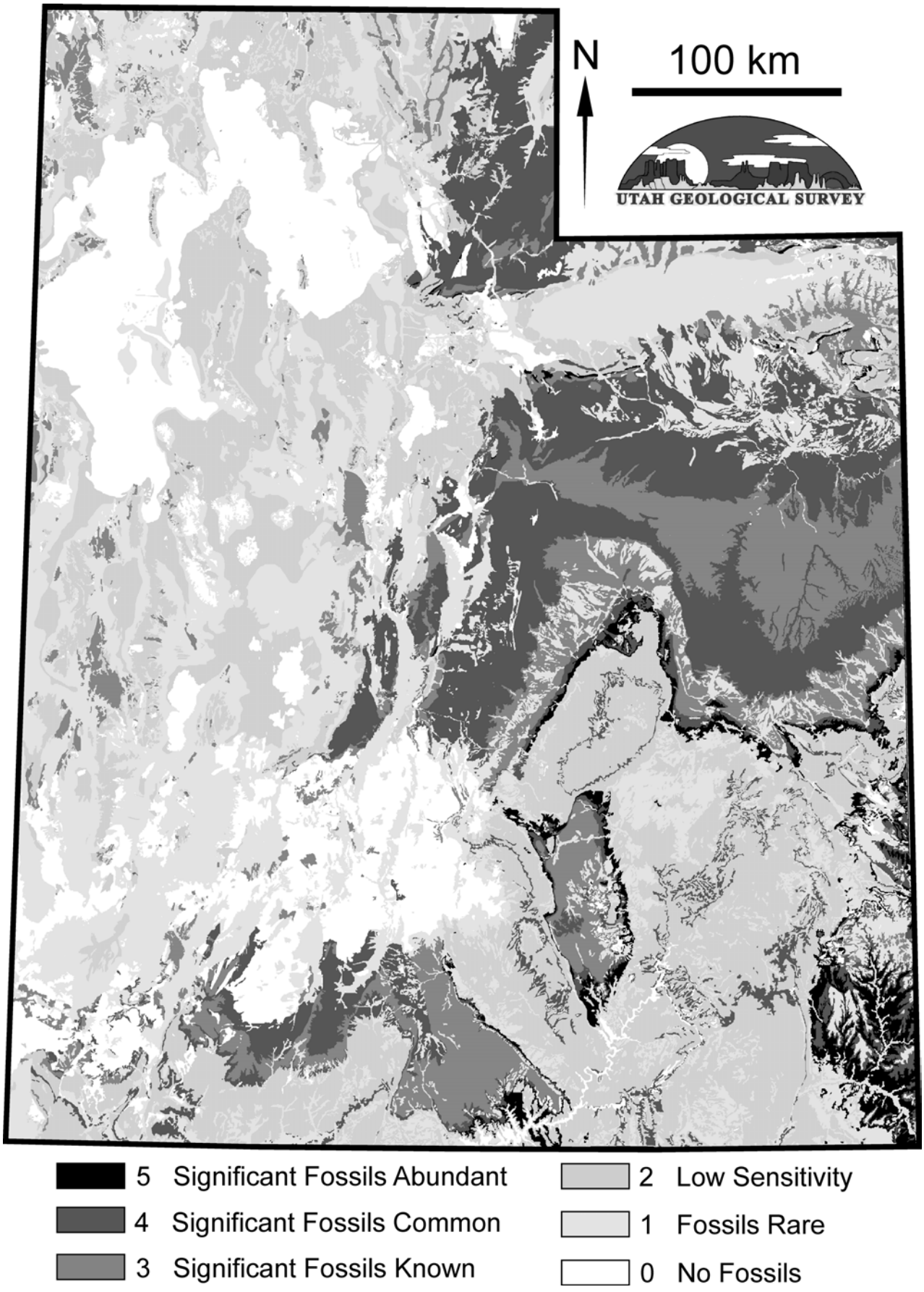

FIGURE 1. Paleontological Sensitivity Map of Utah.

rock units at the member level are mapped and dozens of types of superficial deposits are recognized, providing greater resolution in the resulting paleontological sensitivity maps. Letters from outside agencies requesting the UGS to produce specific 7.5' geologic quadrangle maps are very effective in helping the UGS Geological Mapping Program obtain funds from STATEMAP, a cooperative federal/state geological mapping effort for specific mapping projects of high priority to land managers.

In addition, it is critical that field investigations be conducted because fossils are never uniformly distributed through any rock unit. Field investigations provide an essential test of paleontological sensitivity maps developed from reviewing the paleontological literature.

RECENT UGS PALEONTOLOGY PROJECTS

A number of our recent cooperative projects are described below. These projects all include several components that are generally common to each project: (1) literature search; (2) search of Utah Paleontological Locality Database; (3) acquisition of detailed geological hard copy and/or digital map for the area under investigation; (4) identification of areas of highest potential paleontological significance; (5) field investigations to secure ground truth; (6) data compilation in GIS compatible formats; and (7) compilation of maps, databases and final reports.

St. George Tracksite

In the winter of 2000, landowner Shelden Johnson discovered a significant fossil locality in the Lower Jurassic Moenave Formation on his land in St. George, Utah. The UGS worked closely with the landowners, the City of St. George, and other agencies to ensure that this important fossil discovery was protected for the good of the citizens of Utah and the nation (e.g. Kirkland et al., 2002b). Today, the City of St. George manages the St. George Dinosaur Discovery Site at Johnson Farm. St. George's Dixie State College of Utah now has a paleontology program, and has hosted a conference on the Triassic/Jurassic boundary as a direct result of this discovery (Harris, 2005).

Flaming Gorge Project

The UGS was recently asked by the U.S. Bureau of Reclamation to evaluate the potential impacts of varying water levels at Flaming Gorge National Recreation Area (managed by the National Forest Service) in Utah and along the Green River downstream in Utah (Mathews et al., this volume, fig. 5). Wave action along the shoreline is an active agent of fossil destruction in dammed water bodies, and fluctuations in water depth expand this detrimental effect over a much wider area. Preliminary examination of the most sensitive formations along the shoreline resulted in the discovery of several significant fossil localities (Hayden, 2002; Bilbey et al., 2005). Combining these new data with the state geological map (1:500,000 scale) permitted a reasonable preliminary paleontological sensitivity map to be developed for this area. However, if geological mapping at the 7.5- minute quadrangle scale were undertaken, a much more detailed paleontological sensitivity map would be possible.

Zion National Park Paleontological Survey

The spectacular rocks exposed in Zion National Park, Utah, include many fossiliferous units ranging in age from Permian through Holocene. Important vertebrate fossil-bearing formations include the Triassic Chinle Formation and the Jurassic Moenave and Kayenta formations, among others. In cooperation with the UGS, several National Park Service interns conducted a comprehensive inventory of paleontological resources located within the park (DeBlieux and Kirkland, 2003). The goal of this work was to identify new fossil localities, assess the distribution of fossils within formations and establish baseline paleontological resource data to support the management and protection of fossils.

We identified over 100 new sites as a result of this project. Terrestrial vertebrate body fossils were found in the Shinarump and Petrified Forest members of the Chinle Formation, these included the remains of phytosaurs, aetosaurs, metoposaurs and a possible ornithischian dinosaur. Dozens of new dinosaur tracksites were discovered in the Whitmore Point Member of the Moenave Formation and the Kayenta Formation. These include numerous *Eubrontes* and *Grallator* trackways as well as probable swim tracks.

We used GIS programs to not only record site localities, but also to create paleontological sensitivity maps from recently completed UGS 7.5-minute geologic quadrangle maps (1:24,000 scale) of the park. Because of the vast size of parks such as Zion accurate detailed geologic maps are essential for focusing field assessments on the formations and deposits that have the highest potential for containing important paleontological resources. Modern geologic maps provide several advantages over older maps, including greater detail, more accurate placement of geologic contacts, better division into members and even sub-members, and much more detailed mapping of surficial deposits that cover fossil-bearing strata (Willis et al., 2004). The identification of scientifically important new localities illustrates the value of cooperative projects in the National Parks.

Grand Staircase–Escalante National Monument Wahweap Survey

Over the past four years, the UGS has been funded by the BLM to conduct a paleontological inventory of the lower sandstone and middle shale members of the Wahweap Formation in the southern Kaiparowits Basin in the Grand Staircase – Escalante National Monument (GSENM) within a mile of open roads in the area. In addition to providing data on the distribution of paleontological resources, this study has identified and recovered specimens that are adding to our knowledge of large terrestrial animals during a time interval from which they are poorly known.

The Wahweap Formation preserves the most diverse early-middle Campanian terrestrial fauna in North America, based largely on information gained by the study of microvertebrate fossils collected by wet screenwashing. These studies have documented four freshwater shark species, three freshwater ray species, seven bony fish species, two amphibian species, six turtle genera, two lizard taxa, three crocodilian taxa, eight dinosaur taxa and 23 mammal species (Eaton et al., 1999; Eaton and Kirkland, 2003). However, the turtles, crocodilians, and dinosaurs require more complete skeletal material for specific identification (Kirkland, 2001).

Although no significant crocodilian specimens have been found during the UGS's field investigations, both trionychid and baenid turtle shells have been recovered and are presently under study. Only two dinosaurs have been identified to species-level from rocks of this age in North America (Montana). At GSENM, cranial remains of a new species of long-horned centrosaurine ceratopsian (horned dinosaur) are the most significant dinosaur fossils to be identified so far (Kirkland, 2001; Kirkland and DeBlieux, 2005; Kirkland et al., 2002a; 2005a; 2005b; Titus et al., 2005). A number of associated hadrosaurid (duck-billed dinosaur) skeletons have been identified in the field, although taxonomically critical cranial remains have yet to be identified in these preliminary excavations. The isolated skull roof of a juvenile pachycephalosaur (dome-headed dinosaur) has been collected. Additionally, carnivorous dinosaur remains have been identified at a number of sites, although nothing diagnostic has come to light.

Sevier River Formation Project

We should note that the absence of recorded fossil localities does not equate with an absence of fossils. Prior to the mid-1990s no vertebrate fossil localities were known from the Miocene Sevier River Formation in Fish Lake National Forest of central Utah. Recent discoveries indicate that these rocks preserve the richest Miocene fauna known from Utah or its immediate vicinity (DeBlieux et al., 2002). Ground truth is critical to understanding the distribution of important fossil resources,

so field research and inventories by qualified paleontologists need to be encouraged. In this way, the public will have its fossil resources protected and will gain most from this compelling resource.

CONCLUSIONS

The UGS is particularly well suited to developing management tools for paleontology. As one of the largest state surveys, it employs an experienced paleontological staff, a sizable geological mapping program and a large support staff of experts in GIS software. Not being a federal or state repository, the UGS is free to work with all the repositories in Utah as needs of specific projects warrant. Additionally, the UGS publishes a variety of products from limited runs of reports restricted to specific clients to mass-produced public documents intended for general distribution to libraries and the public.

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